

# Research, Development and Demonstration of Packaged Cooling, Heating and Power Systems for Buildings (BCHP)

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# Agenda

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- Program goals and approach
- Fast Track Facility Preparation
- BCHP Market
- Screening Tool Development
- Screening Tool Sample Results
- Program Progress and Plans
- Summary

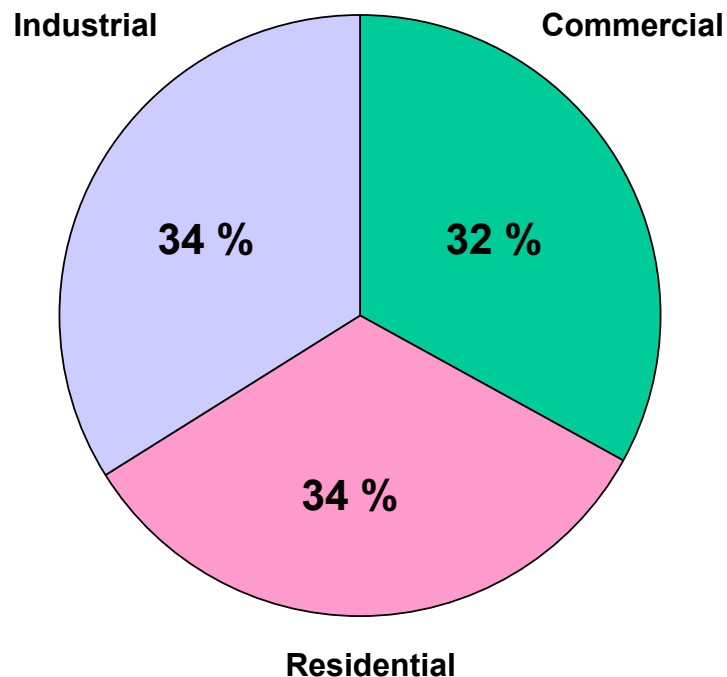
# DOE Goals for BCHP Program

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- Confirm BCHP national energy savings potential (18 GW)
- Assess building market potential and determine preferred BCHP module characterization
- Identify most likely (optimized) BCHP system to achieve significant savings
- Test/Demonstrate BCHP modules that are foundation for future product offerings
- Define benefits of modular BCHP approach – achieving future energy savings

# MARKET OVERVIEW

**Energy demand is driven equally by industrial, commercial, and residential use**

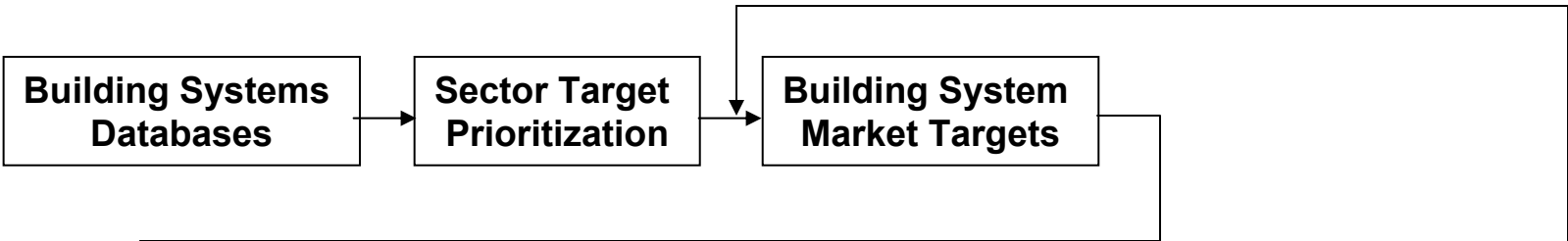


## Characteristics of Attractive Customer Segments

- Average peak load > 100 kW
- Ability to use significant amounts of thermal output:
  - chilled water
  - hot water
  - steam
  - hot air
  - hot process liquid
- Existing user of desiccant system
- High load factor - average energy use / peak use
  - 24/7 operation
  - continuous process manufacturing
- Outage sensitive

# UTC Team Program Activity Flow

## *Market Analysis*

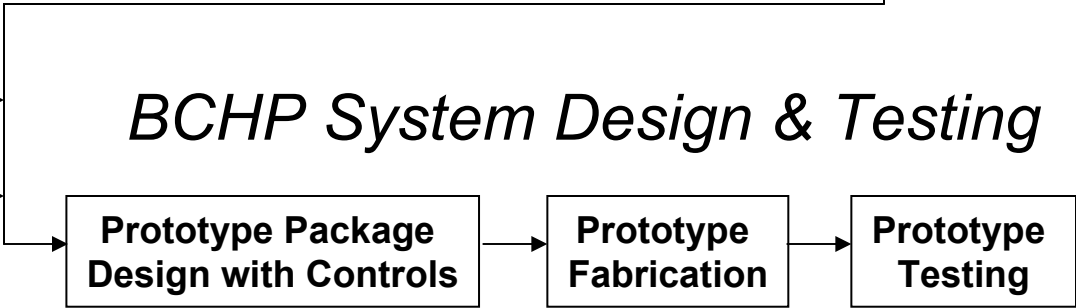


## *Load & Equipment Characterization*



*Fast Track System*  
*Optimized System*

## *BCHP System Design & Testing*



# UTC Team Program Stages

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Proceeds from market screening through prototype demonstration

## Task 1 Project Plan (Nov 01)

## Task 2 Packaged System Concept (Jun 02)

- Market Sector Screening
- Thermally Activated Technologies
- System Concept Definition and Integration

## Task 3 System Optimization and Specification (Aug 02)

- Model Tool Development
- Market Area Characterization and Economic Analysis
- Target Application Selection

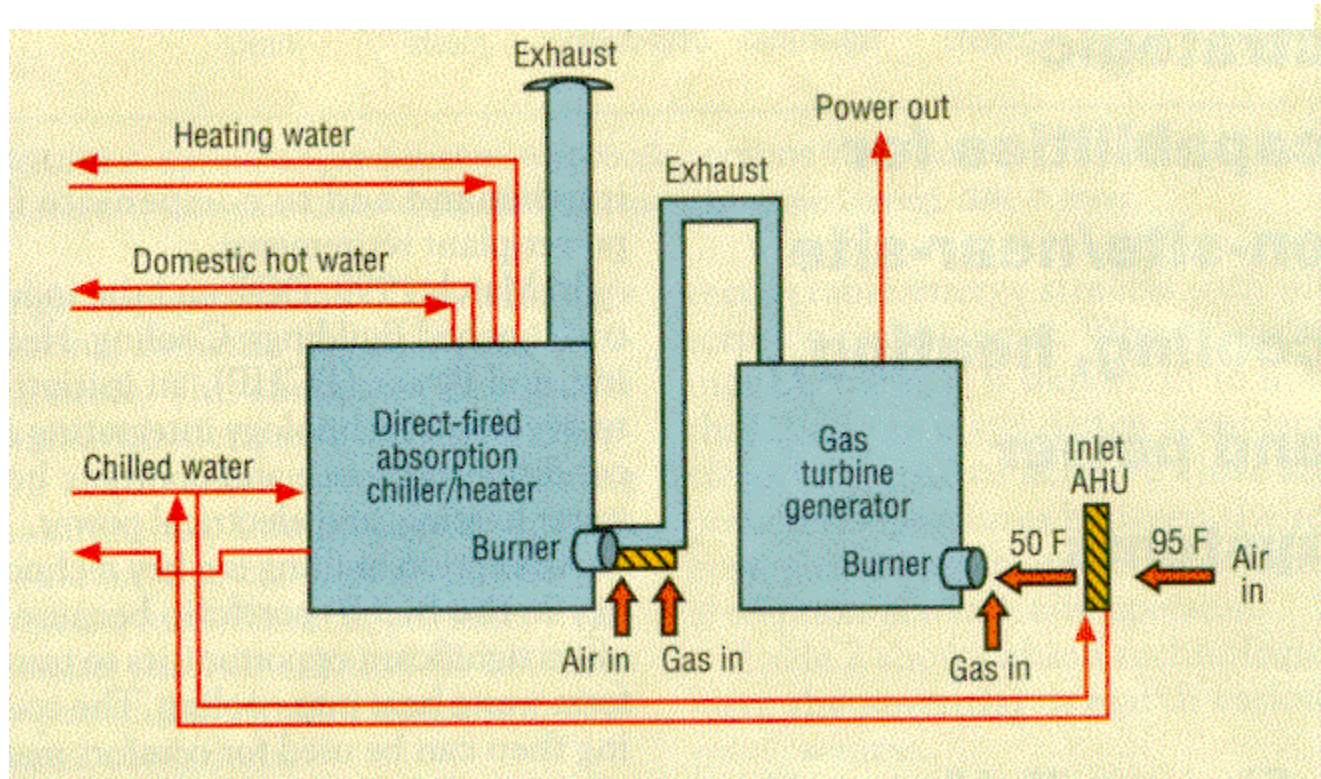
## Task 4 Test Methods, Procedures and Standards (Aug 02)

- Standards and Codes
- Performance Measurement Techniques

## Task 5 & 6 Prototype Develop and Testing (May 03)

- Fast Track Risk Reduction
- Optimized System

# Microturbine Developments are Enabling BCHP



Source: "Absorption Technologies for Buildings: Cooling, Heating and Power Systems (BCHP) Systems, " , by Sweetser, I R., DeVault, R, and Foley, G., Heating/Piping/Air Conditioning Engineering, July 2000, pp. 51- 56.

# Fast Track Facility Preparation



Single Effect Absorption Chiller



400 kW Microturbine



Test Cell



Heat Recovery Unit



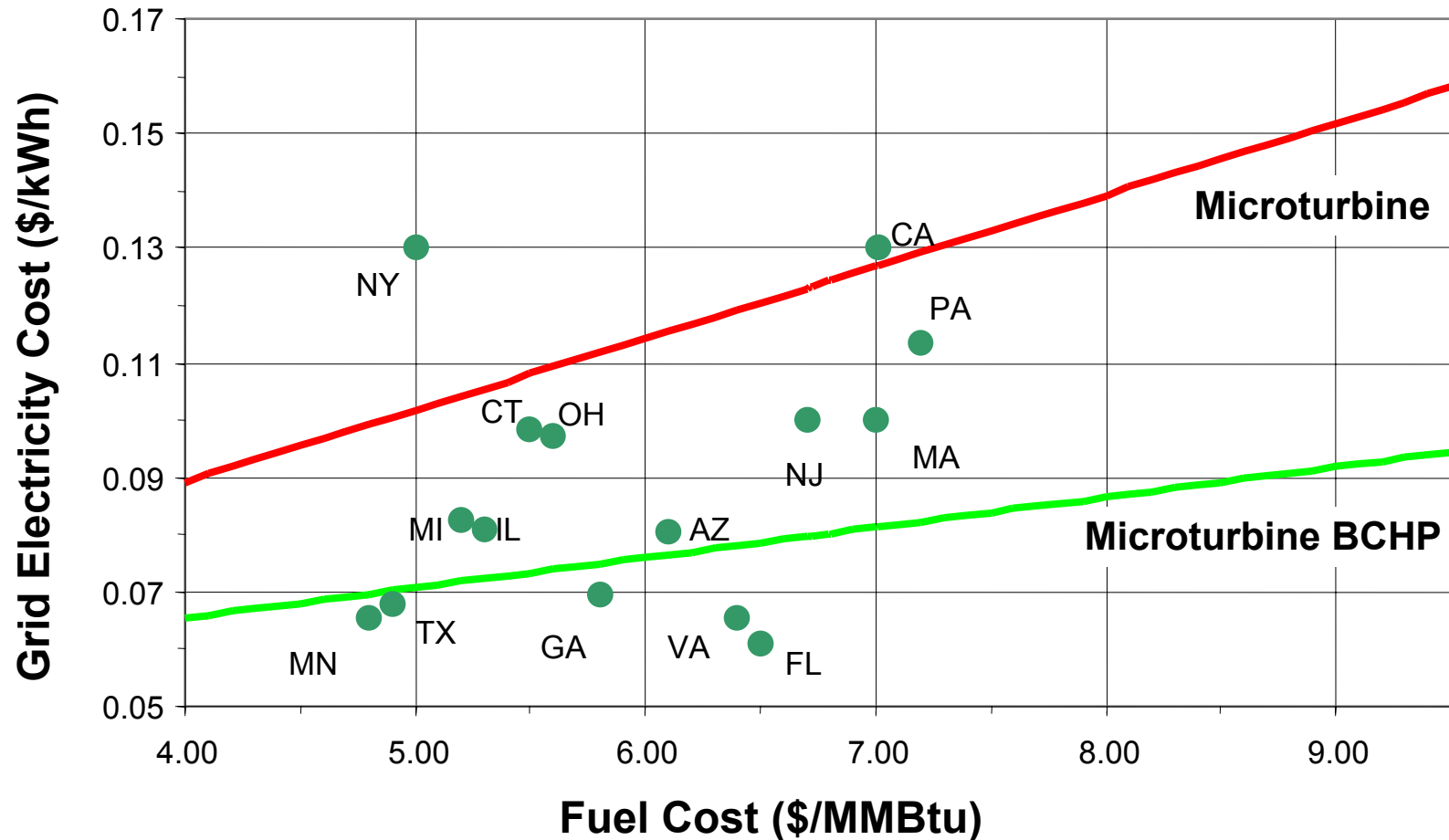
Air Handler Unit



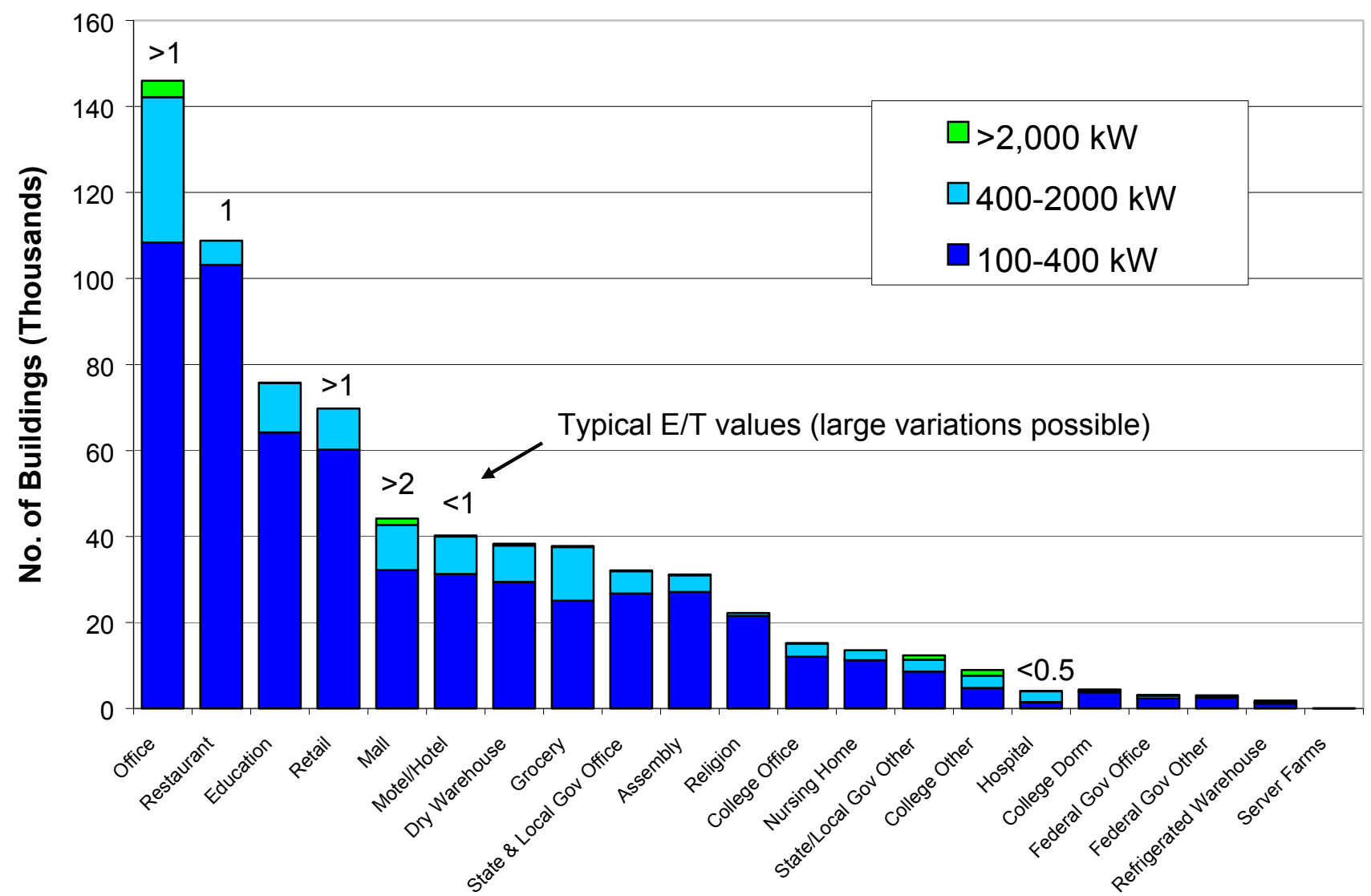
# BCHP Microturbine Competitive in Many States

*Attractive economics for > 40% of US population*

- 4-year customer payback of installed microturbine equipment @ \$700/kW
- No credit taken for reliability, low emissions, or avoided transmission upgrade



# US Commercial Market > 100 kW



Source: MAISY database for continental US commercial buildings

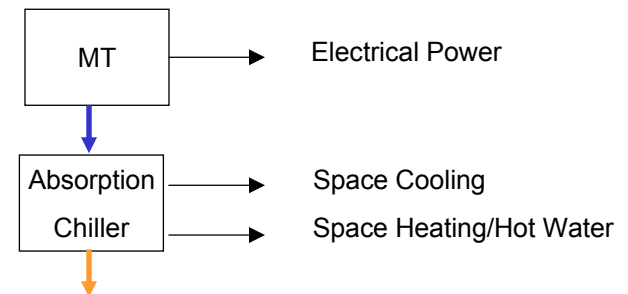
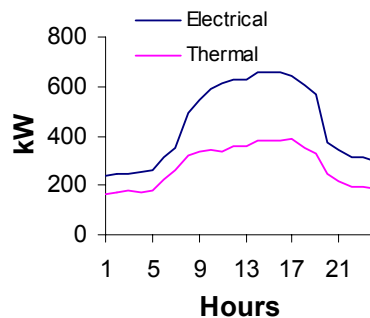
Building Type

# Office Building Waste Heat Utilization Opportunities

*Up to 50% of building services can be met using “free” waste heat*

|               | %LOAD<br>(TYP) | TYPICAL SYSTEM  | CHP SUITABILITY<br>FOR INSTALLED BASE   |   |
|---------------|----------------|---|---|---|
| Space Heating | 28             | Gas Boiler (large, > 25000 ft <sup>2</sup> )<br>Gas Furnace (small) | Large buildings: waste heat driven hot water (especially for perimeter heating)                                     | Y |
| Space Cooling | 11             | Vapor compression chiller (large)<br>Direct expansion (small)       | Large buildings: waste heat driven absorption chiller to produce chilled water. Use existing fan coils/air handlers | Y |
| Lighting      | 29             | Standard fluorescent lighting                                       | None  | N |
| Hot Water     | 9              | Gas Boiler (large)<br>Gas Water Heater (Small)                      | Waste heat driven   | Y |
| Other         | 23             | Includes computers, elevators, telecommunications etc.              | Electric loads  | N |

Typical load profiles



# Screening Tool Development

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## *Tools for rapid evaluation of design space*

- A series of increasingly complex screening and assessment tools have been developed to assist in definition of BCHP modules that will provide an optimum integrated system
- Tools can be applied to assess effects of many application and system variables
- Screening tools can be applied to selected building types to match current and future energy requirements and product designs and controls needed for BCHP systems.

# Screening Analysis Parameters

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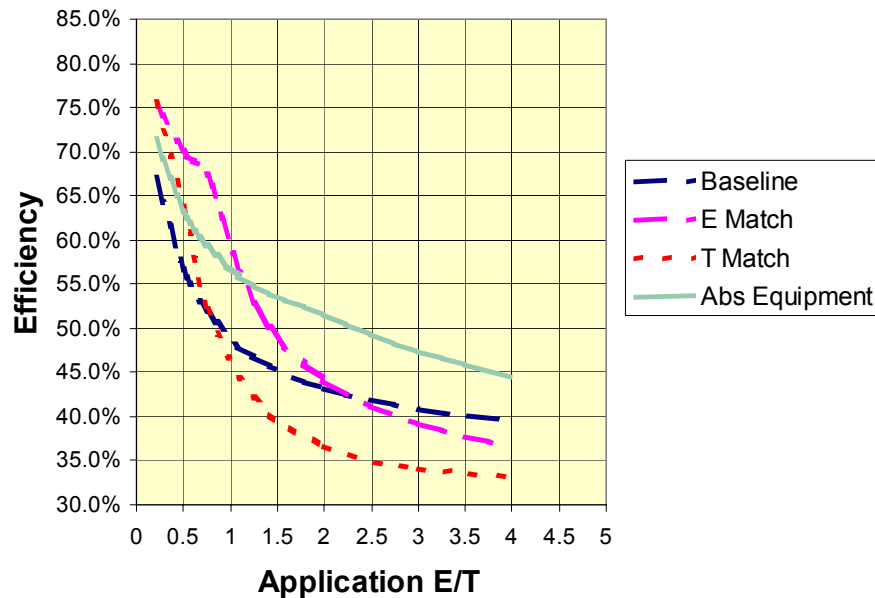
- Microturbine configuration:
  - simple cycle
  - recuperated cycle
  - recuperated cycle with Organic Rankine Cycle (ORC)
- Operating and design matching strategies
  - matching electricity requirements
  - matching thermal requirements
  - substitution of absorption chillers for electrically-based cooling
- Number of BCHP units and building load
- Building electrical/thermal ratio range:  $0.25 < E/T < 4.0$
- Percent load used for electric A/C (to assess absorption chiller opportunities)
- Annual electric load factor
- Allowable costs of BCHP equipment
- Performance and cost tradeoffs
- State energy costs
- Climatic regions

# Screening Tool Sample Result – Microturbine Configuration

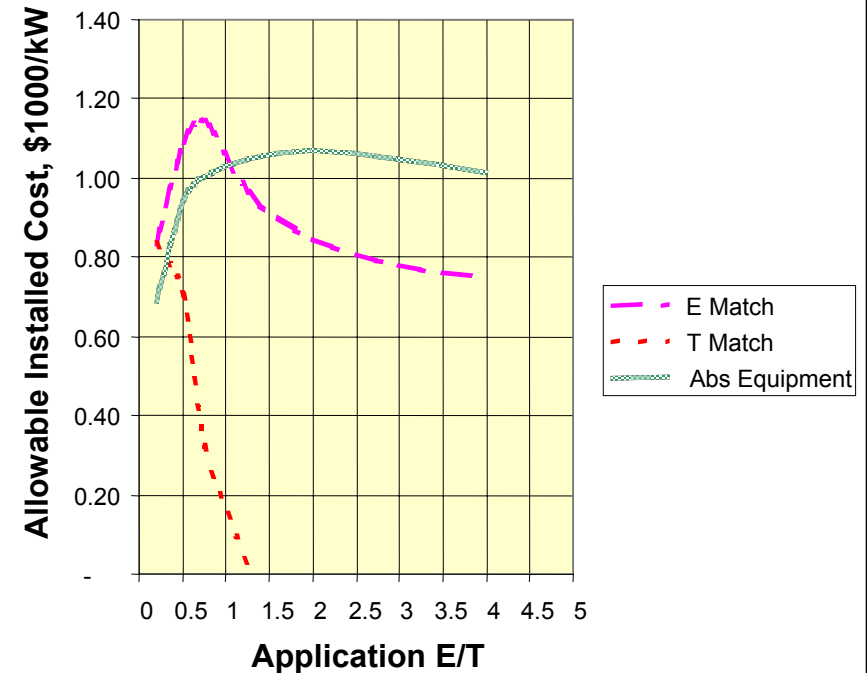
## *Efficiency and allowable cost for recuperated cycle*

Inputs: state, electric demand and load factor, number of microturbines, payback period, percent electric load used for AC

**Effect of E/T and Matching Strategy**



**Economic Analysis**

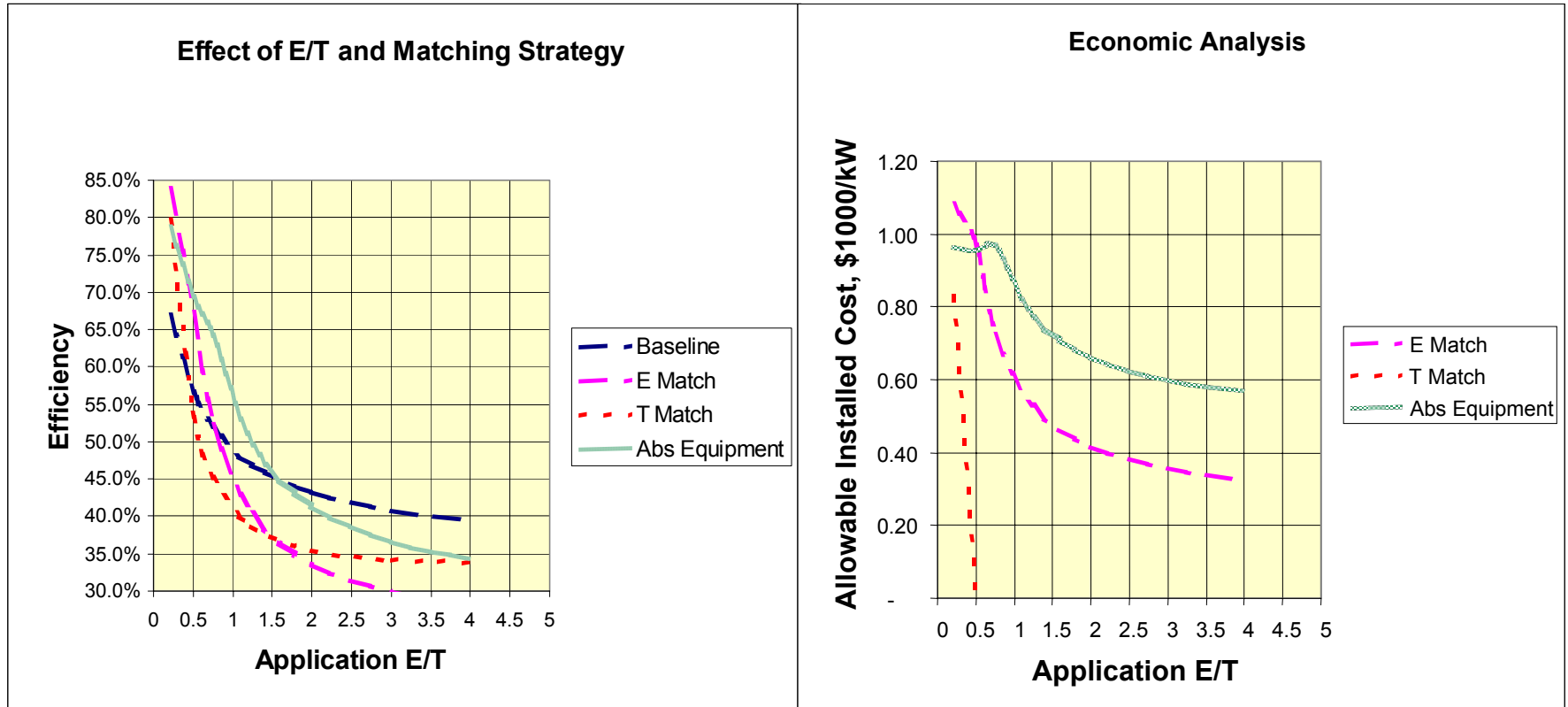


Observation:  $E/T < 1$  Match E strategy favorable  
 $E/T > 1$  Absorption strategy favorable

# Screening Tool Sample Result – Microturbine Configuration

## *Efficiency and allowable cost for simple cycle*

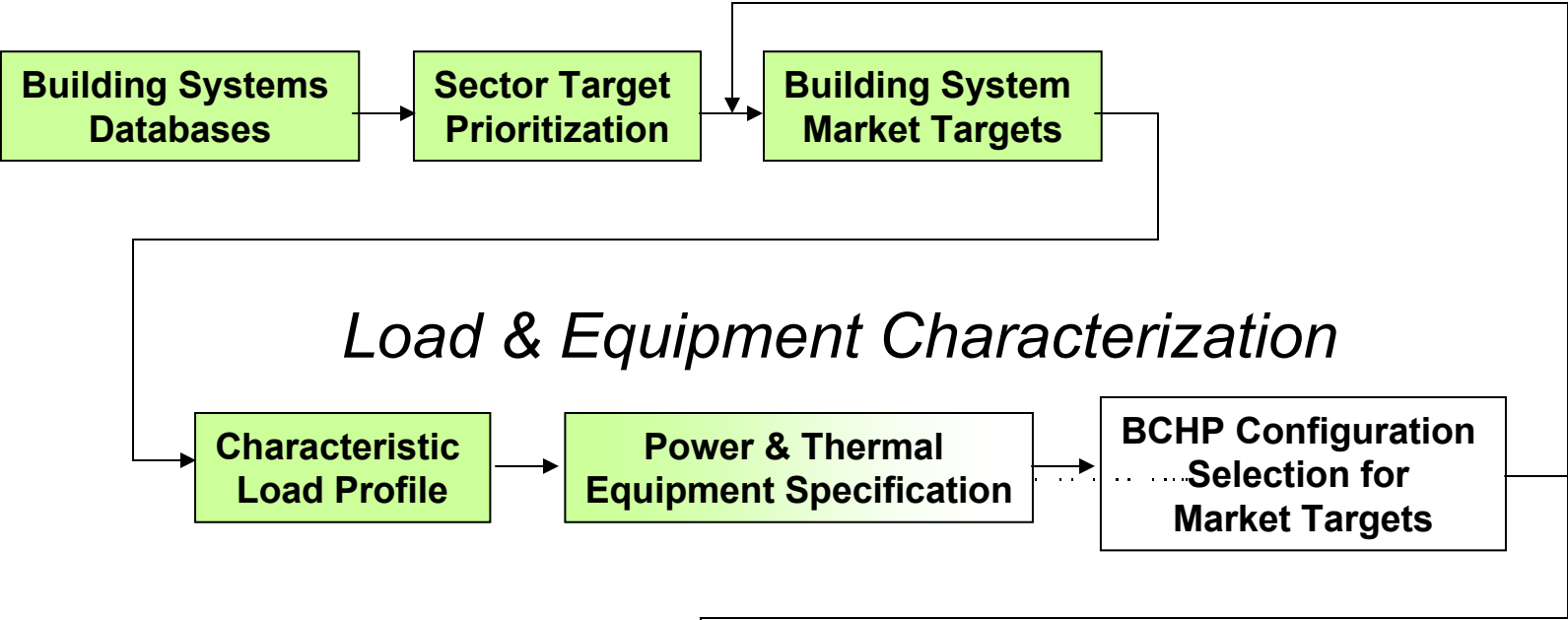
Inputs: state, electric demand and load factor, number of microturbines, payback period, percent electric load used for AC



Observation:  $E/T < 1.5$  Absorption strategy favorable;  
but allowable cost lower than recuperated cycle

# Program Progress

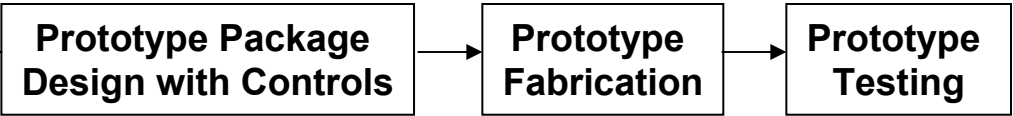
## *Market Analysis*



*Fast Track System*

*Optimized System*

## *BCHP System Design & Testing*





# Future Key Milestones Lead to BCHP Demonstration

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## 2002

- Select optimized configuration (Jun)
- Finalize target applications (Aug)
- Define packaged system performance measurement techniques (Aug)
- Assemble Fast Track Risk Reduction System (Jun)
- Modify absorption chiller for optimized system (Oct)
- Test Fast Track Risk Reduction System (Dec)

## 2003

- Install Optimized System (Feb)
- Test Optimized System (Apr)
- Complete data analysis and final report (May)

# Summary

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## UTRC Program Accomplishments

- Identified states and building stock amenable to BCHP
- Cost model and rating methodology developed
- Preparation of test facility and fast track system initiated

## BCHP systems have great public benefit

- Achieve fuel utilization >70%
- Reduce CO<sub>2</sub> emissions
- Expand customer choice for reliable, secure power
- Provide customer with electricity, building heating/cooling, and hot water
- Avoid outages and infrastructure investments